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Influence of flowering and additional fertilization on physical and sensory aspects of arabica coffee

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ABSTRACT: In Caparaó region, Brazil, in areas above 1000 m high, a second flowering (called late or from March) is common to take place, causing changes in the crop management for those intending to produce specialty coffees. The objective of this study was to evaluate physical and sensory aspects of arabica coffee from the Caparaó region, produced in traditional and late plantations in the same fields, using two fertilization regimes, one recommended by specific literature and another with the addition of extra fertilizers (33%), respecting the proportions amid them. The employed factorial analysis allowed identifying the interaction between the two levels of nutrition and the two harvests, for the analyzed attributes. The extra addition of fertilizers provided a reduction in the mean score of the fragrance/aroma and overall sensory attributes in the traditional harvest; and in the late harvest, it alone was responsible for raising the scores of the following sensory attributes: flavor, aftertaste, acidity, balance and total. The added extra amount of fertilizer, unassisted, altered the coffee physical aspects, reducing their defects/imperfections.

Key words: *Coffea arabica* L.; coffee nutrition; crop management; March flowering; specialty coffees

Influência da florada e adubação adicional em aspectos físicos e sensoriais de café arábica

RESUMO: Na região do Caparaó, em áreas acima de 1.000 m de altitude, é comum ocorrer um segundo surto de florada (chamada de tardia, ou de março) que gera modificações no manejo de colheita para aqueles que pretendem produzir cafés especiais. O objetivo deste trabalho foi avaliar aspectos físicos e sensoriais de café arábica da região do Caparaó, produzido em lavouras com colheitas tradicional e tardia nos mesmos talhões, usando dois regimes de adubação, sendo um o recomendado pela literatura específica e outro, com a adição de 33% de fertilizantes extras, respeitando-se as proporções entre eles. O fatorial utilizado permitiu identificar a interação entre os dois níveis de nutrição e as duas colheitas para os atributos analisados. A adição extra de fertilizantes proporcionou redução na nota média dos atributos sensoriais fragrância/aroma e geral, na colheita tradicional, e a colheita tardia, isoladamente, foi responsável pela elevação das notas dos seguintes atributos sensoriais: sabor, finalização, acidez, balanço e total. A quantidade extra de fertilizantes adicionada, de forma isolada, alterou os aspectos físicos dos cafés, reduzindo-lhes os defeitos/imperfeições.

Palavras-chave: *Coffea arabica* L.; nutrição do cafeeiro; manejo cultural; florada de março; cafés especiais

Introduction

The Caparaó region, composed of several municipalities, is located in two Brazilian states, with one part in the southwest of Espírito Santo and the other one in Minas Gerais, in the Zona da Mata. Its main economic activity of the primary sector is mountain coffee farming, which plays a key role in socioeconomic development.

Many factors directly influence the chemical composition of the coffee bean and thus, its quality. Among these, the genetics of varieties, cultural and postharvest management, and the climate stand out (Scholz et al., 2013).

A scale of number-based reproductive phenological phases of coffee has been described by Pezzopane et al. (2003), being it: 0 (dormant bud); 1 (swollen bud); 2 (closed bud); 3 (flowering); 4 (post-flowering); 5 (pinhead); 6 (fruit expansion); 7 (green); 8 (cane-green); 9 (cherry); 10 (raisin); 11 (dry). However, it is known that histological analysis is the best method for accurately evaluating the transition of phenophases, despite its difficult practical use (Paula Carvalho et al., 2014).

In the coffee plant, intervals between flowering and the bean maturation period are determined by climatic conditions. Altitude, latitude and the climate define the growth and maturation of fruits in the plant (Paula Carvalho et al., 2014). Silva Neto et al. (2018) confirmed the relation between beverage quality and bean formation time, when observing a strong influence of shading and the coffee plant phenology on the beverage sensory characteristics. Zaidan et al. (2017) stated that there is influence of varieties and environments on coffee quality.

In microregions where the dry period coincides with the harvest time, it is faster to change the condition from cherry bean to partially dry bean, requiring harvesting in a shorter period of time, which causes unevenness in the harvested beans. In microregions with higher humidity in the harvesting period, the fruit stay a longer time in the plant; however, there may be a greater degradation of these. In both cases, fruits are mixed up at harvest, with different degrees of ripeness, density and moisture content. According to Custódio et al. (2014), in irrigated plants, the flowerings happens at different times.

Coffee growers from the Caparaó region realize that the region occurring coffee flowerings are unequal, with a spacing between them, which exceeds what is verified in the Brazilian coffee industry. It is common to observe flowerings at the beginning and the end of the rainy season, with the latter being commonly referred as “March flowering”.

Until they knew that their products had added value, acknowledged by the coffee quality contests, all fruit were harvested at the same time, usually between May and September, resulting in a high proportion of smaller and defective beans among those that reached full maturity. On the same stems, there are fruits in different stages of development and maturation due to the referred chronological distance of the flowerings (Custódio et al., 2014).

According to studies, it is known that thirteen is the number of essential mineral elements required for the survival of higher plants: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and chlorine (Cl). The first six correspond to macronutrients, which are required in proportionally larger quantities, while the others corresponds to micronutrients (Santos et al., 2015).

The soil is heterogeneous and within it complex reactions occur, involving the nutrients added by fertilizers that, although often present in adequate amounts, are not available for root absorption (Carducci et al., 2014). Taking into account that coffee plantations require nutrient input into the soil in order to replenish the volume exported in the beans, soil fertility needs to be managed to maintain the aimed productivity levels annually. According to Guarçoni (2017), the improvement and maintenance of soil fertility can be achieved through fertilizers.

Since there is no record of recommendation for coffee fertilizers in a similar situation to the one mentioned above, a mutual interest grew, from the academy and the growers, to investigate whether extra fertilizer addition could interfere with the physical and sensory aspects of coffee harvested in two distinct periods in the same fields. The purpose of this research was to evaluate the physical and sensory aspects of Caparaó’s arabica coffee hailing from traditional and late harvests, adding an extra amount of fertilizer compared to the recommendation described in the literature.

Materials and Methods

The research was conducted in the Foquilha do Rio community, partly located in the Pedra Menina district, in the Dores do Rio Preto municipality – Espírito Santo and in Espera Feliz – Minas Gerais (latitude 20°32’3”S, longitude 41°48’17”O). This locality is close to the Caparaó National Park (Parna - Caparaó), southeastern Brazil.

In 2015, five rural properties located in Forquilha do Rio, at an altitude of over 1000 m, were selected for this experiment implementation, meeting the following requirements: a) having a Catuaí Vermelho IAC 44 variety crop; b) having a late flowering (“March flowering”) and selectively harvesting it, with at least one traditional and one late harvest; c) having already been assisted by consultancy and technical assistance by Caparaó Jr. (junior company from the Federal Institute of Espírito Santo – Alegre Campus); d) annually conduct soil sample collection, management and crop treatment, according to technical recommendation; e) performing postharvest in a suspended terrace with coverage; f) storing the coffee in clean and coffee-exclusive storage open containers (“tulhas”) ; g) having already participated in any quality competition and wining awards.

In each farm/plantation, fields with 100 plants were selected, 50 of them having received fertilization according to the traditional recommendation of Lani et al. (2007), in 3 plots, and the other 50 plants had an extra fertilizer installment (4 plots in total), with 1/3 extra fertilizers throughout the crop year. The fertilization occurred in the first week of November, mid-December, early February and the fourth fertilization, when possible, in mid-March.

In each experimental field, 10 simple soil samples were collected under the crown projection, using a stainless steel probe of 0-20 cm depth. Composite samples, originated from the homogenization of simple samples, were sent to a laboratory supervised by a quality-monitoring program from the Brazilian Agricultural Research Corporation (Embrapa) and by the Minas Gerais Interlaboratory Program of Quality Control of Soil Analysis (Profert-MG), in the municipality of Manhuaçu - MG. Table 1 displays the results of soil analysis of each field.

Table 1. Fertility analysis results of the soils of the coffee fields from Forquilha do Rio, Caparaó – ES/MG.

Parameter	Field				
	1	2	3	4	5
MO: dag/dm^3	3.1	5.0	5.0	3.5	4.8
pH: unid	5.9	5.9	5.7	5.8	5.1
P: mg/dm^3	3.7	18.9	7.9	32.5	13.3
K: mg/dm^3	110	267	128	229	164
Ca:$cmol_c/dm^3$	5.1	6.2	5.3	5.0	3.4
Mg: $cmol_c/dm^3$	1.3	1.4	1.4	1.3	0.7
Al:$cmol_c/dm^3$	0.00	0.00	0.00	0.00	0.38
H+Al:$cmol_c/dm^3$	3.00	4.00	4.50	3.80	7.60
S.B:$cmol_c/dm^3$	6.68	8.28	7.03	6.89	4.52
C.E.C:$cmol_c/dm^3$	9.68	12.28	11.53	10.69	12.12
V%:	69	67	61	64	37
%K in C.E.C	3	6	3	6	3
%Ca in C.E.C	53	50	46	47	28
%Mg in C.E.C	13	11	12	12	6
%Al in C.E.C	0.0	0.0	0.0	0.0	3.1
%H+Al in C.E.C	31	33	39	36	63
P-rem.: mg/L	16.7	17.1	16.7	25.1	25.5
S: mg/dm^3	36	42	22	13	22
B: mg/dm^3	0.20	0.20	0.30	0.10	0.50
Zn: mg/dm^3	1.8	3.4	1.2	3.3	1.9
Mn: mg/dm^3	1.0	21.6	7.6	73.6	8.1
Cu: mg/dm^3	1.9	1.9	2.0	2.0	0.8
Fe: mg/dm^3	43	26	52	18	51

pH= acidity and alkalinity measure (water); Ca= calcium; Mg= magnesium e Al= aluminum (KCl 1mol/L method); P= phosphorus; K= potassium; Fe= iron; Zn= zinc e Mn= manganese (Mehlich-1 method); H+Al= Hidrogen+aluminum (Calcium acetate method); O.M.= Organic matter (Colorimetric method); S= sulfur ($Ca[H2PO_4]_2$ in HOAc method); B= boron ($BaCl_{2\cdot2}H_2O$ 0,125% method); S.B= sum of bases; C.E.C= cation exchange capacity; V%= base saturation; %K in C.E.C= potassium percentage in C.E.C; %Ca in C.E.C= calcium percentage in C.E.C; %Mg in C.E.C= magnesium percentage in C.E.C; %Al in C.E.C= aluminum percentage in C.E.C; %H+Al in C.E.C= Hidrogen+aluminum percentage in C.E.C; P-rem= remaining phosphorus value; Cu= copper.

From the interpretations of soil fertility and the fertilizers recommendation, all fields received liming to increase base saturation to (60%), performed between August and September 2015, as advocated by (Lani et al., 2007). The said fertilizations, in turn, were performed in the rainy season, between October 2015 and March 2016, minding the interval of 30-40 days between them. Table 2 displays the formulated fertilizers and the recommended micronutrients for each plant. For plots with treatment composed of 4 fertilizers, an additional 1/3 of the recommended fertilizers for each field were added.

During the maturation period, 8 L of matured coffee (cherry) were selectively harvested in each plot, with the traditional harvesting occurring in August and the late one in November 2016, in the same plants, separated into plots and fields. All harvested coffee were sent to a community postharvest structure, consisting of a 600 L h^{-1} capacity waterless husker, polyethylene boxes for float and demucilated separation and a hanging terrace covered with clear plastic wrap, with cement floor.

The husked coffee was demucilated and disposed separately in the terrace until its drying completed the condition of (12%) beans moisture. At the end of drying, the samples were sent to the Coffee Classification and Tasting Laboratory from IFES - Alegre Campus, for physical and sensory analysis, which occurred in the months of January (physical analysis) and March (sensory analysis) 2017, with all the harvested coffee.

For physical classification, the Brazilian Official Classification Protocol - COB (Brasil, 2003) was employed, determining the number and weight of imperfect-defective beans, total of large flat beans (sieves 17, 18 and 19), medium flat beans (sieves 15 and 16) and small flat beans (sieve 14 and down below).

In order to perform the sensory analyzes, the coffee beans were roasted and tasted according to the Specialty Coffee Association of America protocol, with a scale ranging from 0 to 10 (SCAA, 2015), and the color of roasted coffees being between AGTRON 55 and AGTRON 65. After resting for 16 h, the samples were analyzed for 10 attributes: fragrance/aroma, flavor, aftertaste, acidity, body, uniformity, clean cup, sweetness, balance and overall by 4 "Q-graders" tasters, certified by the Coffee Quality Institute (CQI). A total of 5 cups of 150 mL containing Manhattan-type sample was given for

Table 2. Recommendations of formulated fertilizers and micronutrients for the soils of coffee fields from Forquilha do Rio, Caparaó – ES/MG.

Field	Formulated	Formulated quantity	($FeSO_4$. $7H_2O$)	($ZnSO_4$. $7H_2O$)	($Na_2B_4O_7$. $5H_2O$)	($CuSO_4$. $5H_2O$)	($MnSO_4$. $3H_2O$)
		(g $plant^{-1}$)					
1	24-04-18	472	0	10	10	0	19
2	24-04-10	540	55	6	11	0	0
3	25-05-20	428	0	16	8	0	13
4	21-05-10	450	57	4	13	0	0
5	25-05-15	450	0	10	6	6	13

($FeSO_4$. $7H_2O$)= iron sulfate; ($ZnSO_4$. $7H_2O$)= zinc sulfate; ($Na_2B_4O_7$. $5H_2O$)= borax; ($CuSO_4$. $5H_2O$)= copper sulfate; ($MnSO_4$. $3H_2O$)= manganese sulfate.

each grader, with each cup/portion of the sample having been individually ground, and for each new sample, the grinder went through a purification process. The used concentration was 5.5% m/v, which corresponds to 8.25 grams of ground coffee in 150 mL of water at a temperature of approximately 93 ºC. Mean values of each attribute, obtained by simple mean, were taken into account.

The experiment was analyzed according to a 2 x 2 factorial, having 5 blocks, with two ways of splitting the fertilizer, one with the recommended dose and another with an increase of 1/3, and two harvesting periods, one traditional and the other late, according to the statistical model: $y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$, where: y_{ijk} is the value of the i-th treatment in the j-th plot and in the k-th block; μ is the model general constant (mean); α_i is the i-th level effect of factor A; β_j is the j-th level effect of factor B; $(\alpha\beta)_{ij}$ is the interaction effect between the i-th factor A level and the j-th factor B level; and ε_{ijk} is the experimental error between the i-th factor A level and the j-th factor B level in the k-th block. Data were statistically analyzed by analysis of variance (F test) and mean test (Tukey).

Results and Discussion

The experiment showed good experimental precision for the sensory attributes, with a coefficient of variation below 5% (Table 3), while for the physical attributes, it was between 11.23% and 85.88%, setting medium and low experimental precision, respectively (Table 4). In general, the number of fertilizers and the harvesting period influenced some of the physical and sensory aspects of coffee ($p < 0.05$). Their interaction had significant results for the fragrance/aroma and overall ($p < 0.05$) sensory attributes (Table 3), and non-significant for all physical attributes of the beans ($p > 0.05$) (Table 4).

Extra addition of fertilizers provided a reduction in the mean score of the fragrance/aroma and overall sensory attributes in the coffee harvested in the traditional period. For fragrance/aroma, the mean values fall from 7.61 to 7.42, while the overall mean scores of the coffee decreased from 7.31 to 6.98. Similar behavior is not observed when the late harvesting was employed (Table 5).

Literature that addresses the interference of fertilizers on coffee sensory quality is still inconclusive. It is known that the addition of potassium sources associated with chloride anion can impair production and activity of polyphenoloxidase (PPO), an enzyme directly related to the beverage quality. According to (Angelico et al., 2011), this decrease in PPO enzyme activity can also be caused by increased fruit bagging time and potassium leaching. Copper participates as a PPO cofactor and its reaction with chloride anions may inhibit its activity, with subsequent loss in the produced coffee quality. Chloride anion also has a negative effect on the PPO tertiary structure, denaturing it (Martinez et al., 2015).

It was noticed a superiority of fragrance/aroma and overall sensory attributes scores in the late-harvested coffee

Table 3. Summary of the analysis of variance with the mean squares (MS) of the sensory attributes from the arabica coffee beans response to the fertilization and harvesting period in Caparaó – ES/MG.

Variation source	Variables							
	Fragrance/Aroma	Flavor	Aftertaste	Acidity	Body	Balance	Overall	Total
Grader	0.04353^{NS}	0.06184^{NS}	0.06968^{NS}	0.03092^{NS}	0.06968^{NS}	0.00773^{NS}	0.11189^{NS}	0.70434^{NS}
Harvest	0.27465^{NS}	2.36328**	2.05200**	0.70312**	0.09887^{NS}	1.17309**	1.85668**	50.3039**
Fertilization	0.03051^{NS}	0.12207^{NS}	0.05981^{NS}	0.59082**	0.09887^{NS}	0.20629^{NS}	0.53833*	9.23950^{NS}
Grader x Harvest	0.02726^{NS}	0.10091^{NS}	0.15096^{NS}	0.03906^{NS}	0.01424^{NS}	0.03051^{NS}	0.03702^{NS}	1.25773^{NS}
Grader x Fertilization	0.07609^{NS}	0.00813^{NS}	0.04028^{NS}	0.05696^{NS}	0.05981^{NS}	0.01424^{NS}	0.03377^{NS}	0.42114^{NS}
Harvest x Fertilization	0.44067*	0.12207^{NS}	0.05981^{NS}	0.07812^{NS}	0.20629^{NS}	0.09887^{NS}	0.53833*	9.23950^{NS}
Grader x Harvest x Fertilization	0.02400^{NS}	0.09277^{NS}	0.00773^{NS}	0.11718^{NS}	0.02400^{NS}	0.03051^{NS}	0.09236^{NS}	1.07218^{NS}
Error	0.0852	0.09814	0.11743	0.06103	0.07055	0.06225	0.10961	2.84399
CV (%)	3.85	4.24	4.76	3.3	3.59	3.38	4.53	3.26
General mean	7.56	7.37	7.19	7.47	7.38	7.36	7.3	51.67

^{NS} = statiscally non-significant by the "F" test at the 5% probability level. * = statiscally significant by the "F" test at the 5% probability level. ** = statiscally significant by the "F" test at the 1% probability level.

Table 4. Summary of the analysis of variance with the mean squares (MS) of the physical attributes from the arabica coffee beans response to the fertilization and harvesting period in Caparaó – ES/MG.

Variation source	Variables								
	Numbe	Defwei	Larflat	Medflat	Smaflat	Larmoca	Medmoca	Smamoca	Type
Harvest	31264.28^{NS}	9.975781^{NS}	36.18050^{NS}	50.64153^{NS}	1.845281^{NS}	0.3001250^{NS}	0.004500000^{NS}	0.2761250^{NS}	0.02812500^{NS}
Fertilization	146247.8*	6033.470*	671.0611*	274.7258*	61.86403*	3.960500^{NS}	2.415125^{NS}	2.628125^{NS}	2.628125^{NS}
Harvest x Fertilization	11009.78^{NS}	295.4883^{NS}	2.380500^{NS}	0.01653125^{NS}	0.5527813^{NS}	0.4351250^{NS}	0.2645000^{NS}	0.4961250^{NS}	0.5281250^{NS}
Error	31723	1266.087	84.38019	33.36459	13.66184	1.883438	0.7266875	0.823375	0.921875
CV (%)	51.08	66.03	24.16	11.23	85.88	48.23	43.1	62.04	18.83
General mean	380.69	53.88	38.01	51.4	4.32	2.84	1.97	1.46	5.23

^{NS} = statiscally non-significant by the "F" test at the 5% probability level. * = statiscally significant by the "F" test at the 5% probability level. ** = statiscally significant by the "F" test at the 1% probability level. numbe = number of beans; defwei = defects in weight; Larflat = large flat; medflat = medium flat; Smaflat = small flat; Larmoca = large moca; medmoca = medium moca; Smamoca = small moca; type = type.

Table 5. Mean test for the sensory attributes (SCAA Protocol*) Fragrance/Aroma and Overall of the coffee from the Caparaó plantations, in function of the number of fertilizations and harvesting period.

(No.) of fertilizations	Harvest	
	Traditional	Late
	Fragrance/Aroma	
3	7.61 Aa	7.58 Aa
4	7.42 Bb	7.69 Aa
	Overall	
3	7.31 Aa	7.45 Aa
4	6.98 Bb	7.45 Aa

Means followed by the same uppercase letter in the column or lowercase letter in the row do not differ statistically by the Tukey test at 5%; * Protocol developed by the Specialty Coffee Association of America (SCAA, 2015).

over the traditional-harvested ones. Late harvest raises the mean fragrance/aroma score from 7.42 to 7.69, while the overall score rises from 6.98 to 7.45. According to Clemente et al. (2018), there was a positive effect of boron on caffeine, trigonelline, sucrose, glucose and PPO activity when the beverage quality was evaluated, which may be directly related to the beverage sensory characteristics.

Beverage quality depends, above all, on operations prior to the beneficiation. Post-harvest management, such as beans preparation and drying, is critical to prevent the development of negative fermentative processes that bring harm to the coffee (Santos et al., 2018). Aiming to evaluate the color parameters of natural and pulped coffee beans, done with the manual and mechanical processing, the authors Abreu et al. (2015) state that pulped coffee have a more intense green color when compared to the natural coffee.

According to Silva Neto et al. (2018), in tree-shaded coffee plants, the phenological stage is accelerated, with early flowering, resulting in faster matured beans. Martins et al. (2015) observed the influence of climatic conditions on coffee productivity and quality. Making an analogy with the weather conditions that determine the intervals between flowering and the coffee bean maturation period, Silva Neto et al. (2018) state that early ripening is one of the factors responsible for the quality loss in the very ripe “cherries”, due to their effect on the metabolism of chlorogenic acid and tryptophan.

The harvesting period did not significantly affect the physical analyzes held ($p > 0.05$). However, regardless of the harvesting period, there were changes in the attributes related to physical quality as a function of the amount of applied fertilizer.

With the extra fertilizers addition, there was a reduction in both the amount and weight of imperfect-defective beans (Table 6). Most of the imperfections were composed by broken beans, one of the intrinsic defects and due to processing problems, contrary to what was disclosed by Paiva Custódio et al. (2018), where the lowest percentage of total intrinsic defects is related to irrigation management. Other recurring imperfections, but not dependent on the studied treatments, were shell-type, internal void (“chocho”), burnt or poorly granulated beans. Puncture was not among the most visible imperfections, and this is due to the region milder climate (Custódio et al., 2018).

It must be emphasized here that the postharvest, which could be a variation factor in these evaluations (Caixeta et al., 2014), do not compose a source of variation because all coffee were processed in a single installation and following a single procedure, contrary to the methodological procedures described by other authors, where each grower supplies their already benefited coffee.

Although there were fewer defective beans with the extra addition of fertilizers, the size distribution of no-defect beans pointed to a higher proportion of large flat beans when this extra addition was not applied. On the other hand, both the number of medium and small flat beans rose with the increasing nutrient addition. Although the objective of this study was to evaluate the physical and sensory characteristics of coffee beans, the study by Lacerda (2014) shows an increasing quadratic response to zinc doses when the quality of raw beans was evaluated.

In the same way it was verified for the physical attributes, regardless of the harvesting period, the extra addition of fertilizers provided a reduction in the acidity sensory attribute score, varying ($p < 0.05$) from 7.56 to 7.31. As described above, science is still moving towards unraveling the relation between soil fertility, nutrition and coffee sensory aspects, attribute by attribute. According to Martinez et al. (2018), quality-related attributes are maximized when copper concentration is low in coffee plant leaves, directly affecting production and chemical composition of the coffee.

Harvesting period interfered in five of the sensory attributes, regardless of the number of fertilizations. Flavor, aftertaste, acidity, balance and total had higher scores in the late harvest. Only from 2014 onwards that growers began to harvest selectively, preserving the fruits still green on the plants for a late harvest, usually between October and December. This behavior further consolidates late harvested coffee as the best in sensory aspects of the Caparaó region (Table 7).

In different production processes, striving for coffee quality is the major concern. With improved quality, coffee becomes a product with superior market value. However,

Table 6. Mean test for the number of imperfect-defective beans, defective beans weight and sieve of coffee plantations from Caparaó, as a function of the number of fertilizations.

No. of fertilizations	No. of defective beans	Defective beans weight (g)	Sieve (g)		
			Large flat	Medium flat	Small flat
3	434 A	71.2 A	43.8 A	47.7 B	2.57 B
4	263 B	36.3 B	32.2 B	55.1 A	6.1 A

Means followed by the same letter in the column do not differ statistically by Tukey test at 5%.

Table 7. Mean test for sensory attributes (SCAA Protocol*) flavor, aftertaste, acidity, balance and total of Caparaó crop coffee, as a function of harvesting period.

Harvest	Sensory attributes				
	Flavor	Aftertaste	Acidity	Balance	Total
Traditional	7.20 B	7.04 B	7.38 B	7.24 B	80.88 B
Late	7.55 A	7.36 A	7.57 A	7.48 A	82.46 A

Means followed by a same letter, in the column, do not statistically differ from each other by the F test at 5%; * Protocol developed by the Specialty Coffee Association of America (SCAA, 2015).

the beverage quality is determined by its flavor and aroma, which are related to the chemicals substances in the beans (ABIC, 2017). Other factors are also directly associated with the quality of the coffee beverage, with the environmental, genetic, cultural and harvesting methods standing out among them (Scholz et al., 2013).

Conclusions

The extra addition of fertilizers provided a reduction in the mean score of the fragrance/aroma and overall sensory attributes in the traditional harvest, and the late harvest alone was responsible for enhancing the following sensory attributes: flavor, aftertaste, acidity, balance and total.

The added extra amount of fertilizer, unassisted, altered the physical aspects of the coffee, reducing their defects/imperfections.

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